

Project Report

Arizona Iceberg Lettuce Research Council

For period
(July 2003 through June 2004)

Breeding high quality and disease resistant iceberg lettuce cultivars for Arizona

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Growers and shippers throughout the region

SUMMARY:

Our objectives are to incorporate disease resistance into crisphead lettuce cultivars and breeding lines adapted to low desert production conditions. Major breeding efforts targeted lettuce big vein, fusarium root rot, powdery mildew, and combining multiple resistances. In all programs, horticultural traits, adaptation, and resistance to tipburn are considered essential. In 2003 we identified new candidate sources of resistance to fusarium and big vein. In replicated tests, we confirmed resistance of previously identified germplasm to big vein and powdery mildew, obtained preliminary data on inheritance of resistance to Fusarium root rot. Advanced breeding lines were evaluated for resistance to big vein, tip burn, bolting resistance, and powdery mildew.

Introduction

Production of iceberg lettuce from December through April is centered in the low desert region of Arizona and California, and is critical to maintaining a year round supply of high quality lettuce. Lettuce production is continually faced with preexisting and new challenges; therefore, development of improved cultivars with superior adaptation and pest resistance is important for sustaining this industry. Our research emphasizes the development of landmark cultivars adapted to early, middle, or late season conditions with resistance to pests, physiological disorders and environmental stresses.

The USDA lettuce breeding project has had a desert program for many years, both in Arizona and in the Imperial Valley. Several landmark cultivars have been released which became the backbone of desert production for many years: Empire, Merit, Climax, and Vanguard. Since the release of those cultivars in the late 1950's additional cultivars were released that have also been useful, including Autumn Gold, Winterset, and Vanguard 75. In recent years, most of the desert production has been in the Yuma area. Therefore nearly all of our on-site work has been done in Yuma and have focused on the production concerns of this region. The objectives of this research is to develop iceberg lettuce breeding lines possessing 1) bolting resistance for early fall production, 2) big vein and powdery mildew resistance for mid-winter production, 3) tipburn resistance for late spring production and 4) Fusarium root rot resistance (Fusarium wilt)

Procedures

Field and greenhouse trials were conducted for big vein. In greenhouse trials, 12 seedlings per line are inoculated with *Olpidium brassicae* from symptomatic roots. These seedlings are transplanted into infested soil, grown in a cool greenhouse, and recorded for disease incidence over the following eight weeks. Greenhouse assays were performed for nine F₄ Pacific x (Pacific x Pavane) breeding lines; 80 previously untested plant introductions (PIs), and 8 previously selected PIs. Field trials were conducted in Yuma with 14 F₄ Winterhaven x Pacific and 14 F₄ Winterhaven x 95-103 breeding lines and 20 cultivars. Plantings were direct seeded in late October and evaluated for head type and disease incidence in February. Plants with no symptoms that had good head characteristics were selected.

Field trials were planted for bolting resistance in early September. Eight 87-714-8 x Autumn Gold F₅, 1 87-714-8 x Autumn Gold F₄ and 2 Autumn Gold x Tiber F₅ were planted and non-bolting good heading types were selected at field maturity. Tip burn was evaluated in a late December planted field trial; 10 heads per line were scored for tip burn incidence. Three Salinas x Vanguard 75, and 23 Winterhaven x Pacific were tested.

Powdery mildew resistance was evaluated in natural infested field and greenhouse trials. F₂ and F₃ Salinas x Soraya and F₂ Darkland x Clarion were planted and selected for powdery mildew resistance in greenhouse trials. Eleven cultivars were planted in greenhouse trials to confirm resistance found in earlier trials. These were evaluated for disease incidence on cotyledons, and first true leaves, and also for adult plant severity. Nine Big Boston x Winterhaven F₄ lines were evaluated in field trials. Breeding lines were direct seeded and disease free plants with good head characteristics are selected at maturity.

Field and greenhouse tests were done to confirm the race of Fusarium present in Arizona, identify new sources of resistance and determine inheritance of resistance to Fusarium.

Results and Discussion

A. Lettuce big vein resistance.

In mid-winter field trials in Yuma, selections were made for good head characteristics within big vein free breeding lines. Nine selections were made from F₄ Winterhaven x Pacific (big vein resistant). Forty selections were made from F₄ Winterhaven x 95-103.

Resistant iceberg breeding lines are being developed based on resistance from the cultivar Pavane, a latin lettuce. Three years of greenhouse testing was completed for 9 F₄ Pacific x (Pacific x Pavane) breeding lines (Table 1). No lines were more resistant than Pavane in any year. Two lines, 01-2060 and 01-2062 demonstrated resistance comparable to Pavane; a third line, 01-2058, had resistance higher than Pavane when totaled across all years. These lines have been crossed to Winterhaven for breeding resistance cultivars adapted to low desert production conditions.

Plant introductions (PIs) continue to be screened for resistance to big vein in greenhouse evaluations. The majority of breeding lines were highly susceptible to big vein when compared to Pavane (0%) and Margarita (67%). Ten PIs with less than 35% symptomatic plants were selected for further greenhouse testing. Replicated greenhouse tests were conducted with selected advanced PIs. Among these, 2 leaf lettuces, PI 289042C (cv. Ausztraliai Sarga) and PI 289035C (cv. MayKing) were as resistant as Pavane in 2 years of testing (Table 3). These PIs will be tested further in greenhouse and field plantings.

B. Fusarium root rot

Fusarium, a problem in Japan since 1955, is becoming a serious pathogen of lettuce in Arizona. Three physiological races of the pathogen are known in Japan: 'Costa Rica #4' is resistant to race 1 and susceptible to races 2 and 3; 'Banchu Red Fire' is resistant to race 2 and susceptible races 1 and 3; and 'Patriot' is susceptible to all three races. No germplasm has been reported resistant to race 3. Our greenhouse (Arizona and California isolates) and field data (Arizona) indicate that race 1 is present in California and Arizona.

- a. Inheritance of resistance. Limited data from putative F₁ individuals (55 plants from 21 crosses tested) from crosses of 'Costa Rica No. 4', 'Rivergreen' and 'Salinas' (resistant) x 'Vanguard' and 'Vanguard 75' (susceptible) indicate that resistance to race 1 in 'Costa Rica No. 4', 'Rivergreen' and 'Salinas' is recessive. The F₁ data were supported by a limited sample (27 plants) of an F₂ family from a cross 'Salinas 88' (resistant) x 'Vanguard' (susceptible). Data from a naturally infected field planting were inconclusive for technical reasons.
- b. New sources of resistance. In cooperation with Mike Matheron (UA Cooperative Extension) and Kevin Ford (Keithly Williams Seed co.), several romaine lettuce cultivars had consistently low percentage infection in September plantings in 2002 and 2003 while several other romaines were severely infected. The resistant romaine cultivars appeared to have the highest known level of resistance to race 1. Their performance will be confirmed in field and greenhouse tests.

C. Tipburn Resistance

Thirty-six breeding lines and 12 cultivars were evaluated for tip burn resistance in a late spring planting at Yuma, AZ. Tip burn was observed in every genotype. Data for high performing genotypes and select cultivars are shown on Table 3. Ten genotypes from Winterhaven x Pacific and three from Salinas x Vanguard 75 were selected for further breeding.

D. Bolting resistance

Plantings were made in early September for selection of bolting resistant germplasm. Poor germination occurred in the trial due to high temperatures. Regardless, bolting resistant lines with high quality heads were identified 87-714-8 x Autumn Gold F₅, 87-714-8 x Autumn Gold F₄, and Autumn Gold x Tiber F₅. These lines will be trialed again in 2004/05.

E. Powdery mildew

An early spring field planting was conducted in Yuma, AZ for further selection of PM resistance and heading type in Big Boston x Winterhaven. Nine F₄ lines were evaluated, and no powdery mildew was found on any of these breeding lines. Light mycelium coverage was observed on susceptible checks. One genotype was selected with iceberg head characteristics, and 3 additional lines were identified with better than average heading. All of these will be backcrossed to Winterhaven.

Greenhouse testing has confirmed a high level of resistance to PM in the butterhead cultivar Bremex, having low incidence and severity (Table 4). Development of F₂ progeny from crosses with Bremex and adapted crisphead cultivars has been completed, backcrossing is currently underway. Field and greenhouse trials will be conducted using this new germplasm. Resistance in the cultivars Clarion and Soraya are being introgressed. Greenhouse based selection identified 8 resistant F₂ genotypes from Salinas x Soraya. Further testing of F₃ families identified 2 highly resistant families, 24 resistant plants were selected from these for field testing. Five F₂ genotypes from Darkland x Clarion were selected for resistance, and will be tested further.

Table 1. Percent big vein symptomatic plants in 9 F₄ lines of Pacific x (Pacific x Pavane) tested in replicated greenhouse trials in 2001, 2002, and 2003.

Line	Big Vein Symptomatic Plants							
	2001		2002		2003		total	
	No. Tested	%	No. Tested	%	No. Tested	%	No. Tested	%
01-2058	36	47	36	42	36	25	108	38
Pavane	36	56	36	28	35	43	107	42
01-2060	36	44	36	67	33	30	105	48
01-2062	36	50	36	67	35	26	107	48
01-2059	36	69	36	69	36	17	108	52
01-2063	36	56	36	72	36	31	108	53
01-2057	36	53	35	77	33	55	104	62
01-2064	36	58	36	67	36	61	108	62
01-2061	35	50	36	69	36	81	108	67
01-2065	36	78	36	86	34	62	106	75
Great Lakes 65	36	86	36	94	36	78	107	86

Table 2. Percent big vein symptomatic plants in a replicated greenhouse evaluation.

Line	type	Percent Symptomatic		Status
		2002	2003	
289042C, cv. Ausztraliai Sarga	leaf	8	31	retain
Pavane	latin	58	33	check
289035C, cv. MayKing	leaf	27	39	retain
Margarita	butterhead	na	43	check
289015B	<i>L. altaica</i>	8	44	drop
288244	romaine	36	55	drop
289015C	<i>L. altaica</i>	8	56	drop
Great Lakes 65	iceberg	100	58	drop

Table 3. Tip burn incidence in 10 mature heads from 13 breeding lines and 8 cultivars.

Line	Pedigree	Generation	No. heads with tip burn ^z
03-2746	Winterhaven x Pacific	F _{3:4}	1
03-2767	Winterhaven x Pacific	F _{3:4}	2
03-2775	Winterhaven x Pacific	F _{3:4}	2
03-2757	Winterhaven x Pacific	F _{3:4}	3
03-2777	Salinas x Van 75	F _{2:3}	3
03-2742	Winterhaven x Pacific	F _{3:4}	4
03-2752	Winterhaven x Pacific	F _{3:4}	4
03-2784	Salinas x Van 75	F _{2:3}	4
03-2760	Winterhaven x Pacific	F _{3:4}	5
03-2762	Winterhaven x Pacific	F _{3:4}	5
03-2768	Winterhaven x Pacific	F _{3:4}	5
03-2788	Winterhaven x Pacific	F _{3:4}	5
03-2745	Salinas x Van 75	F _{2:3}	5
Salinas			5
Gabilan			1
Tiber			4
Vanguard 75			5
Winterhaven			8
Green Lightning			8
Legacy			8
Calicel			10

^z per ten head evaluated

Table 4. Powdery mildew incidence and severity on 11 cultivars in greenhouse evaluations.

Cultivar	Lettuce Type	No. Plants Tested	Percent Plants with Infected Cotyledons	Percent Plants with Infected Leaves	Average Disease Severity
Bremex	Butterhead	16	12.5	37.5	1.19
Clarion	Butterhead	16	12.5	100	3.44
Soraya	Butterhead	16	75	100	3.50
Anthem	Butterhead	16	100	100	3.56
Darkland	Romaine	16	100	100	3.56
Allegiance	Butterhead	16	93.75	100	3.88
Waldmann's green	Green Leaf	16	62.5	100	4.06
Clemente	Romaine	16	87.5	100	4.81
Salinas88	Iceberg	16	100	100	4.81
Salinas	Iceberg	16	100	100	4.88
Autumn Gold	Iceberg	16	100	100	5.00

^a/ Disease severity; 0 = 0% sporulation, 1 = 1-20, 2 = 21-40, 3 = 41-60, 4 = 61-80, 5 = 81-100.